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REAL PROPERTY MAINTENANCE ACTIVITY (RPMA) PROGRAMS: ANALYSIS OF NAVY MANPOWER REQUIREMENTS

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NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN DIEGO, CALIFORNIA

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San Diego, California 92152

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This report, the third in a series related to the forecast of long-range, aggregate base operating support (BOS) manpower requirements, describes the development of equations to forecast that portion of BOS manpower that performs real property maintenance activity (RPMA) functions at all major Navy shore bases. The resultant RPMA manpower forecasting models--foreign and domestic--can be used to evaluate Navy BOS manpower required to perform RPMA for programmed levels of Navy shore facilities.

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FOREWORD

The research described here was conducted in support of Navy decision coordinating paper Z1186-PN (Fleet Demand for Support Manpower), subproject Z1186-PN.06 (Forecasting Long-range Manpower Requirements), and was sponsored by the Deputy Chief of Naval Operations (Manpower, Personnel, and Training). The objective of this subproject is to develop long-range, aggregate planning models to forecast Navy requirements for officer, enlisted, and civilian manpower.

This report is the third in a series related to the forecast of long-range, aggregate base operating support (BOS) manpower requirements. Previous reports described the development of manpower-estimating equations for naval stations/air stations and training complexes (NPRDC TRs 82-29 and 83-26). This report describes the development of equations to forecast that portion of BOS manpower that performs real property maintenance activity (RPMA) functions at all major Navy shore bases. The resultant RPMA manpower forecasting models--foreign and domestic--have potential applications at the claimant and CNO programming levels. They can be used by the OPNAV staff to evaluate Navy BOS manpower required to perform RPMA for programmed levels of Navy shore facilities.

The contracting officer's technical monitor was Mr. Thomas A. Blanco.

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SUMMARY

Problem

The Navy does not have established analytic procedures for estimating total base operating support (BOS) manpower requirements. The absence of appropriate analytic tools has weakened the Navy's ability to respond to budget cuts in BOS programs. This, in turn, has the potential for degrading the capability of the naval shore facilities to support the missions of the fleet.

Objective

The objective of this research and development effort was to develop analytic models containing equations that relate Navy manpower performing real property maintenance activity (RPMA) functions to facility workload measures.

Approach

Special emphasis was placed on the selection of workload indicators that are routinely used, forecasted, and readily available in the Navy's program plans to permit easy use of the final models. Data were collected on historic BOS-RPMA manpower, host-user relationships, facility size, and other facility characteristics. These data were assembled into a data base organized by geographic location for fiscal years 1981 and 1982. These data were then analyzed using multiple regression and exploratory data analysis techniques.

Results

Results showed that total BOS-RPMA manpower was primarily relatable to various measures of facility size. Separate models were developed for domestic and foreign geographic complexes, based on total building area. In addition, for domestic complexes, alternative models were developed that considered type of building usage (i.e., housing, storage).

Conclusions

Requirements for BOS-RPMA manpower are primarily driven by the size of the physical plant at shore complexes. The quantification of this relationship should provide Navy analysts with a better means for estimating and justifying their outyear requests for BOS-RPMA manpower.

Recommendation

The models specified herein should be implemented on a computer to facilitate testing and adaptation to user needs. Preferably, the computer would support an interactive "user-friendly" environment to allow hands-on access by Navy planners.

CONTENTS

LIST OF TABLES

INTRODUCTION

Problem

The problem of forecasting the manpower resources required to support planned force levels has received increasing visibility throughout the Navy's planning and programming organizations. The problem is heightened with the movement toward a 600-ship/15-battle-group Navy: The emphasis on procurement for new ships, aircraft, and weapon systems, in conjunction with the President's otherwise austere budget policies, has led to a reduction in resources allocated to support programs. Cognizant Navy planners feel that these reductions have occurred because of the inability to project support requirements systematically as a function of future force levels during the programming phase of the Planning, Programming, and Budgeting System (PPBS). These planners have voiced a clear need for improved analytical methods, models, and data bases to support long-range planning. Of special interest are models that quantify the relationship between support manpower requirements and the size, complexity, and operation of the fleet. Forecasting base operating support (BOS) manpower requirements has been especially difficult because of the diverse functions and indirect fleet support missions of BOS activities. In addition, when regional support activities (e.g., public work centers (PWCs) and naval supply centers (NSCs)) support various fleet operations in a given geographical area, it is difficult to determine the relationship between BOS providers and recipients.

Previous efforts conducted to determine BOS manpower required to support the naval stations/air stations and naval training activities[1,2] demonstrated that such requirements could be related to the demand for services imposed by resident forces, shore-based populations, and facility characteristics. The analysis of BOS manpower at training activities[2] demonstrated that the real property maintenance activity (RPMA) portion of BOS manpower is related primarily to facility characteristics; and the remaining BOS requirements, which are largely personnel-oriented, to the size of the population served.

Objective

The objective of this research effort was to develop a means for forecasting the BOS manpower required to perform RPMA functions at all Navy shore activities. The forecasting methodology had to be formulated such that it could substantiate the need for BOS-RPMA manpower authorizations based on standard program measures available in the Program Objectives Memorandum (POM) process. BOS-RPMA manpower requirements are removed from force levels in the sense that force levels drive the need for base support services, which, in turn, drive the requirement for physical facilities (real property) and their related maintenance. While the broad objective of this research project was to define the overall serial relationship, this particulr analysis had to focus on the latter set of relationships.

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[1]Hudak, P., King, R., & Rhodes, C. A model for estimating Navy manpower in base operating support programs (NPRDC TR 82-29). San Diego: Navy Personnel Research and Development Center, February 1982. (AD-A111 538)

[2]King, R., Hudak, P., & Ganeshan, J. A model for estimating the base operating support (BOS) required to support Navy training activities (NPRDC TR 83-26). San Diego: Navy Personnel Research and Development Center, November 1982. (AD-A132 287)

Background

The inability of Navy analysts to relate BOS resources to the forces they support in large part stems from inadequacies in the planning data bases and the failure of the program element (PE) structure to separate "mission" from "support" resources. Since FY 1979, however, a concerted effort has been made to identify BOS programs and their corresponding resources more clearly. Beginning with FY 1981, financial and manpower data reported for the Operations and Maintenance, Navy (O&MN) appropriation to the Navy Cost Information System (NCIS) have been broken down by function, using the activity group/subactivity group (AG/SAG) nomenclature developed from the historic Budget Classification Code (BCC) structure. This AG/SAG structure was applied not only to O&MN funding, but also to military and civilian manpower data and to the Military Pay, Navy (MPN) appropriation.

The two primary AGs associated with base operations are (1) F3--Base operations support--other, and (2) F4--Base operations--real property maintenance activity. The analysis described here is primarily directed toward AG F4, which consists of the four SAGs described in Table 1. In addition, a distinct but equivalent set of SAGs corresponding to RPMA functions fall under AG G1--Consolidated cryptologic program. Finally, in FY82, naval construction batallion units (CBUs) reported military manpower at the AG F4 level of detail, with no SAG specified. The total military and civilian end-strength for FY81-FY82 by AG/SAG for all activities is shown in Table 1.

APPROACH

In this effort, the RPMA manpower described in Table 1 was matched with RPMA workload indicators on an activity-by-activity basis and models that estimate manpower as a function of RPMA workload were developed. Manpower and activity identification data were obtained from the Navy Cost Information System (NCIS); and workload or facility characteristics data, from the Naval Facilities Engineering Command (NAVFAC).

Earlier research (see Footnote 1) found that PWCs contributed significantly to supplying BOS-RPMA services to activities. Therefore, before workload could be matched accurately to workforce, a procedure had to be formulated to account for the recipients of PWC services. Furthermore, because NCIS does not contain activity-specific manpower data for the Naval Industrial Fund (NIF) PWCs, these data had to be obtained directly from NAVFAC and a special RPMA manpower data base built.

Data Sources

The main source of workload data was the Facilities Inventory and Planning System (FIPS), an automated information system maintained by NAVFAC to (1) provide a single source of data describing facilities for use in planning, management, and inventory, and (2) determine the facilities required at shore activities to accomplish assigned missions. These purposes are met through (1) the Navy Facilities Assets Data Base (NFADB), which provides, for each Navy facility (land, building, structure, utility), data on location, acquisition, outgrants, measurements, construction, condition, utilization, and disposal, and (2) the Shore Facilities Planning System (SFPS), which produces a file of basic facility requirements, compares these requirements with current assets, and provides a plan for satisfying deficiencies or disposing of surpluses. NFADB represents the basic source of historic data for the RPMA analysis, while SFPS provides the means for actually using the RPMA model for outyear forecasts.

Table 1

Real Property Maintenance Activity (RPMA) End Strength
By Activity Group/Subactivity Group (AG/SAG)

SAG	Title--Description[a]	End Strength[b] FY81	FY82
	AG F4--Base Operations--Real Property Maintenance Activity		
FA	Maintenance and repair of real property. Includes expenses specifically identified and measurable to maintenance and repair that can be accomplished with the approval authority of the activity's commanding officer (CO) or at a level above the CO.	8,266	8,037
FB	Minor construction. Includes expenses specifically identified and measurable to minor construction that can be accomplished within the approval authority of the CO or at a level above the CO.	325	319
FC	Operation of utilities. Provides for procurement/production and distribution of utilities, including operation of electrical generating plants, heating plants, water plants, sewage and waste systems, air conditioning and refrigeration plants, and purchase of other utilities.	1,638	1,276
FD	Other engineering support. Includes shore base support functions not included above: public works engineering, custodial services, refuse collection, fire protection, and other similar logistics services.	7,884	7,504
--	Construction battalion unit (CBU) manpower. CBU military manpower reported at the F4 level of detail—no SAG specified.	0	239
Total		18,113	17,375
	AG G1--Consolidated Crytologic Program		
GJ	Maintenance and repair of real property. See description above.	214	218
GK	Minor construction. See description above.	0	0
GL	Operation of utilities. See description above.	21	20
GM	Other engineering support. See description above.	137	135
Total		372	373
Overall Total		18,485	17,748

[a]Source—NAVCOMPTINST 7101.2 of 14 January 1981.

[b]Total Navy active duty and civilian actual end strength.

Data Preparation

NFADB provides a list of unit identification codes (UICs) for (1) activities that provide RPMA services either directly or by purchase from PWCs or private contractors and (2) activities that actually occupy building space or use property maintained by the former activities. These UICs are called RPMAUICs and USERUICs respectively. The list of USERUICs does not include UICs for activities that do not permanently occupy buildings but that receive other types of BOS services (notably, homeported squadrons or visiting ships). Thus, the property-oriented RPMAUIC-USERUIC relationship is well suited to the study of RPMA manpower.

Review of the complete list of RPMA providers and recipients revealed that a given activity can (1) provide RPMA services to one or more recipients, (2) receive RPMA services from one or more providers, or (3) both provide and receive RMPA services. In some cases, an activity may even provide part or all of its own RPMA services. Because of the multiplicity of these RPMAUIC-USERUIC relationships, activities had to be aggregated into "complexes" so that workload measures could be matched with RPMA manpower. This was done by using additional data fields representing geographic locations to produce 105 geographically-based complexes of activities--78 domestic complexes and 27 foreign complexes.[3] These complexes are listed in Table 2. For each complex, the total RPMA workforce was defined by summing the manpower of RPMAUICs within that complex while, at the same time, keeping a well-defined linkage to USERUICs within the complex and the facilities that they occupied. The complexes are diverse in size in terms of both RPMA manpower and building floor area. In FY 1982, the RPMA staff size for complexes ranged from 1 to 2,740, with an average of 267. Building area (in 100,000s of square feet) ranged from 18 to 34,247, with an average of 3,925.

In addition to the RPMAUIC, NFADB records for Navy facilities contain a data element called the category code number (CCN), which indicates how real assets are used (e.g., as a runway, ammunition pier, recruit barracks, etc.), as well as its unit of measure (e.g., square feet, number of berthing spaces, acres) and condition ("adequate," "substandard," or "inadequate" for buildings, structures, and utilities; "improved," "semi-improved," "unimproved," or "other" for land). CCNs and combinations of CCNs were assembled to create workload variables to relateo workload to RPMA manpower requirements.

Workload Variables

Previous research on estimating BOS manpower required to support Navy training activities (Footnote 2) showed that RPMA manpower associated with training activities was functionally related to facility size. Facility size is generally constant at a particular location over a relatively short-term interval. It was expected to be a significant driver of RPMA manpower requirements of a shore complex, independent of the nature of primary missions: More building area at a location naturally would require more manpower for maintenance.

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[3]For a detailed description of this procedure, see Hodak, P., Barash, M., & Windle, S. A model for estimating Navy manpower in real property maintenance programs (Tech. Rep.). Arlington, VA: MATHTECH, Inc., June 1983.

Table 2

Navy RPMA Manpower by Geographic Complex

Geographic Complex	FY82 Manpower
Domestic Locations	
Alaska, Adak	141
California, Camp Pendleton	21
California, Centerville Beach	6
California, El Centro	83
California, Lemoore	213
California, Long Beach	58
California, Miramar, San Diego	195
California, Moffett Field	174
California, Monterey	121
California, Oakland/Alameda	1,248
California, Oakland, Navy Regional Medical Center	73
California, Port Hueneme	272
California, Point Sur	9
California, San Diego	2,356
California, Stockton	127
Connecticut, New London	267
Florida, Homestead	19
Forlida, Jacksonville	17
Florida, Key West	188
Florida, Mayport	151
Florida, Orlando	214
Florida, Pensacola	805
Florida, Volusia City	850
Georgia, Athens	20
Georgia, Atlanta	48
Georgia, Kings Bay	1
Hawaii, Naval Regional Medical Clinic	3
Hawaii, Pearl Harbor	1,891
Idaho, Idaho Falls	3
Illinois, Glenview	121
Illinois, Great Lakes	733
Karsas, Olathe	4
Louisiana, Naval Air Station	114
Louisiana, Naval Support Activity	83
Maine, Brunswick	129
Maine, Cutler	61
Maine, Winter Harbor	31
Maryland, Annapolis	435
Maryland, Bainbridge	9
Maryland, Bethesda	241
Maryland, Patuxent River	6
Massachusetts, South Weymouth	122
Michigan, Mount Clemens	22
Mississippi, Construction Battalion Center, Gulfport	134
Mississippi, Naval Home, Gulfport	24
Mississippi, Meridian	135
New Jersey, Lakehurst	101
New York, Brooklyn	86
New York, Scotia	3
Nevada, Fallon	111
North Carolina, Camp Lejeune, Naval Regional Medical Center	56
North Carolina, Cape Hatteras	2
Ohio, Cleveland	15
Oregon, Coos Bay	10
Pennsylvania, Mechanicsburg	142
Pennsylvania, Philadelphia	34
Pennsylvania, Philadelphia, Navy Regional Medical Center	90
Pennsylvania, Willow Grove	127
Rhode Island, Newport	304
South Carolina, Beaufort	47
South Carolina, Charleston	136
Tennessee, Memphis, Naval Air Station	264
Tennessee, Memphis, Navy Regional Medical Center	19

Table 2 (Continued)

Geographic Complex	FY82 Manpower
Domestic Locations (Continued)	
Texas, Chase Field	189
Texas, Corpus Christi	405
Texas, Dallas	103
Texas, Kingsville	160
Virginia, Norfolk	2,284
Virginia, Portsmouth	143
Virginia, Quantico	3
Virginia, Virginia Beach	538
Washington, Bangor/Bremerton	272
Washington, Pacific Beach	6
Washington, Whidbey Island	221
Washington, DC	86
Washington, DC Area--Prince Georges County, Maryland	54
Washington, DC Area--Talbot City, Maryland	732
West Virginia, Pendleton City	51
Total	18,860
Foreign Locations	
Bermuda, Naval Air Station	183
Bermuda, Naval Facilities Engineering Command	2
Cuba, Guantanamo Bay	334
Galeta Island, Canal Zone	9
Guam	1,347
Iceland, Keflavik	334
Italy, Naples	211
Italy, Sigonella	374
Japan, Atsugi	200
Japan, Misawa	44
Japan, Okinawa, Fleet Activities	17
Japan, Okinawa, Naval Security Group Activity	20
Japan, Sasebo	189
Japan, Yokosuka	1,606
Korea, Commander, Naval Forces, Korea	30
Middle East, Commander Forces Flag Administration Unit	22
Newfoundland, Argentia	71
Panama Canal Zone	86
Philippines, Subic Bay	2,740
Philippines, Subic Bay, Navy Regional Medical Center	23
Puerto Rico	478
Scotland, Edzell	25
Spain, La Maddalena	29
Spain, Rota	575
United Kingdom, England, London	67
United Kingdom, Thurso	29
West Australia, Holt	136
Total	9,181

Facility size can be measured in various ways. One possible and available way is the physical size of buildings (i.e., square feet of building space). The size of a facility can also be represented by such descriptors as miles of roads, acreage, and capacity of utilities. For the analysis, land records provided the data on acreage, which was classified as improved, semi-improved, unimproved, and other (only acreage classified as improved or semi-improved is maintained). Capacities of utilities were aggregated by complex (i.e., generating capacity of electric, gas, etc.) as well as other measures related to utilities such as miles of pipes, miles of communications lines, etc.

Because the Navy categorizes building area by usage, it was possible to determine whether certain types of area generate greater workload than other types. The types of "usage" considered in the analysis were family housing, unaccompanied housing, recruit barracks, warehouses, hangars, and "other." In addition, building area was classified as Navy-owned or leased.

The workload variables also include measures more closely related to the mission or mission areas of a complex, such as miles of runway, warehouse building space, feet of piers and wharfs, capacity of classrooms, miles of communications lines, and number of hospital beds.

Table 3 lists all workload variables that were considered in the analysis.

Analysis

A cross-sectional analysis was performed on the 105 complexes to find variables that best explain the level of RPMA manpower. A cross-sectional approach was followed instead of time-series because RPMA manpower is inseparable from other BOS manpower prior to FY81. FY82 data were used to derive the model; and FY81 data, to validate it. The quality of models can be measured by the stability of coefficient values from year-to-year and the predictive value of one year's equation on another year's data.

Marine manpower was excluded from the analysis. Also, since reserve manpower was not reported by AG/SAG in the NCIS, it was excluded. The RPMA manpower that appears in the NCIS under the reserve PEs is not reserve manpower but, instead, active duty Navy manpower that supports the operation of reserve activities.

RESULTS

As expected, building area is the single best workload measure that best explains the level of RPMA manpower. Building area serves not only as a major driver of workload but also, since buildings are associated with almost all types of facilities, as an excellent surrogate of "size" of the total physical plant to be maintained. For example, a power plant is always housed in a building, and runways are always accompanied by control towers and hangars. The building area variable is such a good measure of "size" that no other workload variable is needed.

The following building area "partitions" were investigated to determine if the match of workload to manpower could be improved.

1. Ownership—Navy-owned or leased.
2. Condition--Adequate, substandard, or inadequate.
3. Use—Housing, warehouse, hangar, or other.

Table 3

Candidate Workload Variables

Description of Variable (Unit of Measure)
Sum of improved, semi-improved land area (acres)
Total land area (acres)
Recruit barracks (persons)
Recruit barracks (square feet)
Communication lines (miles)
Family housing dwellings (family units)
Family housing dwellings (square feet)
Heating, source (millions of BTU/hr.)
Aircraft maintenance facilities (square feet)
Electric power plants (kilowatts)
Gas mains (linear feet)
Hospitals (number of beds)
Piers (feet of berthing)
Piers (square yards)
Water and sewer distribution system (linear feet)
Air conditioning, source (tons/hr.)
Roads (square yards)
Runways (linear feet)
Runways (square feet)
Building area, Navy-owned (square feet)
Total building area (all conditions), Navy-owned <u>and</u> leased facilities included (square feet)
Classrooms (persons)
Unaccompanied personnel housing (persons)
Unaccompanied personnel housing (square feet)
Wharfs (feet of berthing)
Wharfs (square yards)
General supply storage buildings (square feet)
Electrical distribution lines (linear feet)

Since it was questionable as to whether leased area should be included as RPMA workload, correlations were calculated for both total Navy-owned and leased area and Navy-owned area only. Also, because leased building area is more often associated with foreign than domestic complexes (less than 1% of domestic building area is leased), correlations were calculated separately for domestic and foreign complexes. As shown in Table 4, the inclusion of leased space does not increase the correlation for domestic complexes, but it does increase the correlation from .70 to .82 for foreign complexes. This result is reasonable considering that, although the Navy is generally responsible for maintaining its foreign facilities, legal ownership in foreign nations is often limited by treaty arrangements. Because of this result, in further analyses, foreign and domestic complexes were considered separately, using total building area and Navy-owned only building area respectively as workload variables.

Table 4

Domestic and Foreign Complexes Correlations of
RPMA Staff Size with Building Area
(Navy-owned only and Navy-owned and leased)

Building Area	Complexes		
	Domestic	Foreign	All
Navy-owned	.93	.70	.79
Both Navy-owned and leased	.93	.82	.83

The partitioning of area according to building use and condition is discussed on pages 10 and 11. Also, although alternate functional forms of the model (e.g., log-linear and polynominal) were explored, none of the forms improved the model fit of the data enough to justify their use.

Models for Domestic Complexes

Basic Model

The basic aggregate model that best explains RPMA manpower at the 78 domestic complexes using FY82 data is:

$$\text{RPMA Manpower} = -32.6 + .064\ (\text{TOTSQFT}), \tag{1}$$

where TOTSQFT is the floor area (in units of 100,000s of square feet) of Navy-owned buildings.

The coefficient of determination (R^2) of this model is .860, which means that the variable TOTSQFT explains 86 percent of the variation in RPMA manpower from complex to complex. The coefficient (.064) of TOTSQFT is significant at the 99.99 percent confidence level.

The equivalent equation using FY81 data is shown below:

$$\text{RPMA Manpower} = -30.8 + .062\ (\text{TOTSQFT}). \tag{1a}$$

In this case, $R^2 = .847$; and the coefficient (.062) is significant at the 99.99 percent confidence level.

The similarity of the equations for FY81 and FY82 supports their validity. Furthermore, predicting total FY81 manpower on FY81 TOTSQFT using the FY82 model yields an overall manpower of 18,962, compared to the FY81 actual manpower of 18,522, only a 2 percent error for aggregate manpower.

Alternative Models

Use of Building Area. It seemed reasonable to divide use of building area into three types; namely; storage, housing, and other. It was expected that maintenance manpower requirements per square foot would be highest for housing and lowest for storage.

The following FY82 models show results of the regressions performed on domestic complexes of Navy-owned building area partitioned by use:

$$\text{RPMA Manpower} = -32.3 + .079\ (\text{housing}) + .056\ (\text{nonhousing}), \tag{2}$$

where housing is the floor area (in units of 100,000s of square feet) of all family and unaccompanied personnel housing and recruit barracks, and nonhousing is all other building floor area.

The coefficient of determination (R^2) of this model is .861 and both coefficients (.079 and .056) are significant at the 99.99 percent confidence level.

$$\text{RPMA Manpower} = -37.7 + .046\ (\text{storage}) + .071\ (\text{nonstorage}), \tag{3}$$

where storage is the floor area (in units of 100,000s of square feet) of all general supply storage buildings and aircraft maintenance facilities (hangars), and nonstorage is all other building floor area.

The coefficient of determination (R^2) of this model is .864, and both coefficients (.046 and .071) are significant at the 99.98 percent confidence level.

$$\text{RPMA Manpower} = -40.3 + .044\ (\text{storage}) + .062\ (\text{housing}) + .081\ (\text{other}), \tag{4}$$

where storage and housing are defined as above and other is all other building floor area (e.g., hospitals, training facilities).

The coefficient of determination (R^2) of this model is .865, and all coefficients (.044, .062, and .081) are significant at the 99 percent confidence level.

The model's explanatory power does not significantly improve in any of the above equations. However, the sign and relative size of the coefficients in equations (2) and (3) match expectations, and either combination of variables could be substituted for TOTSQFT in the aggregate model. The relative size of coefficients in equation (4),

however, does not match expectations about the relative ordering of workload intensity, but that does not mean it is necessarily wrong. Although it was expected that RPMA requirements would be highest for housing, the coefficients in equation (4) indicate that buildings used for other than housing and storage had the highest demand. This is probably because "other" uses include significant amounts of building area of more complex military buildings (e.g., those used for communications, maintenance, or training; R&D labs; and hospitals).

The FY81 equations for domestic complexes with building area partitioned by use are shown below.

$$\text{RPMA Manpower} = -31.1 + .082\,(\text{housing}) + .052\,(\text{nonhousing}). \tag{2a}$$

$$\text{RPMA Manpower} = -36.8 + .041\,(\text{storage}) + .071\,(\text{nonstorage}). \tag{3a}$$

$$\text{RPMA Manpower} = -38.8 + .039\,(\text{storage}) + .062\,(\text{housing}) + .080\,(\text{other}). \tag{4a}$$

The similarity of the coefficients for the FY81 and FY82 models supports their validity.

Condition of Building Area. In the NFADB Procedures Manual, inadequate facilities are defined as those that are or soon will be unusable and are not worth fixing. Since this definition seems to imply that inadequate facilities are no longer maintained by the Navy, it seems logical to exclude them from workload. The corresponding model has an R^2 of .846. If only adequate building area is regressed against RPMA manpower, the R^2 falls to .778. Thus, it is clear that all building area, regardless of condition, should be included in building area workload. Assuming that this result could be extended to all other candidate workload variables, workload measures were not separated by condition in further analyses.

Mission Variables. Variables unique to complexes with certain missions (e.g., medical, supply) were entered into the regression equation along with TOTSQFT for domestic complexes only. The only intuitively appealing model that resulted involved the supply mission. The R^2 value was .873 on 72 observations. The coefficients for warehouse and all other building area were .023 and .075 respectively, both of which were significant at the 99 percent confidence level. All other mission-related workload variables failed to produce any worthwhile models.

Separate Analysis by PWC. For domestic complexes with a PWC, two dummy variables--an intercept and an interaction with TOTSQFT (slope)--were tested in equation (1). The "slope" dummy entered the equation significantly, while the intercept dummy did not. This indicates that the same increase in building area at a complex with a PWC causes a larger increase in Navy RPMA manpower requirements than at a complex without a PWC. An equivalent version of the one-equation model with the slope dummy variable is shown in equations (5) and (6):

$$\text{MODRPMA} = 20.1 + .041\,(\text{TOTSQFT})\ (\text{for a complex without a PWC}). \tag{5}$$

$$\text{MODRPMA} = 20.1 + .067\,(\text{TOTSQFT})\ (\text{for a complex with a PWC}). \tag{6}$$

The overall R^2 of equation (5) is .888, a modest increase over the .860 obtained with equation (1). This appears to be the best alternative equation for domestic complexes.

Model for Foreign Complexes

The best basic aggregate model that explains RPMA manpower at all 27 foreign complexes, except the complex containing PWC Subic Bay,[4] is as follows:

$$\text{RPMA Manpower} = -23.1 + .106\ (\text{TOTAREA}), \tag{7}$$

where TOTAREA is the floor area of all buildings, expressed in 100,000s of square feet.

The R^2 of this model is .894. The coefficient (.106) of the variable TOTAREA is significant at the 99.99 percent confidence level.

The FY81 equation for the foreign complexes (excluding Subic Bay) is:

$$\text{RPMA Manpower} = -32.8 + .120\ (\text{TOTAREA}). \tag{7a}$$

The R^2 of this model is .856; and the coefficient (.120) is significant at the 99 percent level. Both intercept and slope coefficient have changed considerably from FY82. However, predicting total FY81 manpower on FY81 TOTSQFT using the FY82 model yields an overall manpower of 8,728, compared to the FY81 actual of 9,402, a 7 percent difference for aggregate manpower. No conclusive reasons for the changes were found. To resolve this issue, it appears that additional, more definitive data about manpower functions and workload at foreign complexes, especially those having a PWC, are needed.

Implementation Considerations

The models--domestic and foreign--are intended to be used for Navy-wide planning purposes[5] and not to allocate manpower to individual Navy installations. If RPMA manpower planning must be done on a more detailed level, it should be done on the complex level and no lower, and the "delta approach" must be used. In the delta approach, when building area changes, RPMA manpower is not computed from a zero base; rather,

$$\Delta\text{RPMA Manpower} = b\ (\Delta\text{building area}) \tag{8}$$

is computed, and Δ RPMA manpower is added to the baseyear RPMA manpower to arrive at the new RPMA manpower requirement for that complex. (In equation (8), "building area" stands for TOTSQFT for a domestic complex; and TOTAREA, for a foreign complex. The coefficient b represents the coefficient of the respective building area variable.)

If requirements are calculated from a zero base, differences between complexes not accounted for in the model are ignored, often causing the model to make predictions after building area has increased that are lower than current manpower levels, and vice versa. The model predictions do not tell what manpower level the complex "should" have. If the model underpredicts RPMA manpower, it does not mean that a complex's operation is inefficient; rather, it most likely reflects other special factors at that complex that are not accounted for by the model variables.

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[4]Manpower requirements for the Subic Bay complex (N = 2740) had to be deleted from the analysis because, when included in a model like equation (7), they are by far the most significant outlier. For a full explanation of why the Subic complex was dropped, see Hudak, Barash, & Windle, 1983 (Footnote 3).

[5]Because the equations were derived on the complex level, aggregate manpower must be computed by individual complexes, and the resulting manpower figures summed over all complexes.

If manpower requirements estimations are attempted at a level lower than the complex level, the manpower to which Δ RPMA manpower is added will not be accurately matched with its workload. Such an attempt would undermine the whole purpose of having complexes. A complex is the lowest level at which it is valid to use this model. In summary, the model user should select one domestic model and one foreign model and use them to estimate aggregate RPMA manpower reuqirements. If the user wishes to estimate requirements on a smaller scale, the delta approach should be used at a level of aggregation no lower than the complex level.

CONCLUSIONS

Requirements for BOS manpower to perform RPMA functions are driven by the workload imposed by the size of the physical plant at shore complexes. The quantification of this relationship should provide Navy managers with a better means for estimating and justifying their requirements for BOS-RPMA manpower.

RECOMMENDATIONS

The models specified herein should be implemented in a computing enviroment that facilitates ready hands-on access by Navy planners. The projected facility data from Navy planning systems (SFPS) as described previously can be collected and immediately used as input to the RPMA manpower models.

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